Chapter 6

Summary and Conclusions
In the last two centuries the mankind has progressed considerably and consistently in all the fields. Many scientific and technical revolutions have taken place, which enable us to lead an easy and comfortable life.

These comforts do not come easy, however, and we must pay their price, in terms of many unwanted, and often unhealthy, dangerous and hazardous, consequences of these so-called revolutions. On the negative side of these advancements and achievements is the environmental pollution. And we have to tackle it, using whatever best we have. It is a prime concern of mankind to understand the causes and effects of environment pollution, and to control and prevent this inevitable evil.

Among the atrocious pollutants, heavy metals like zinc and cadmium, and other inorganic anions like fluoride hold prime positions, as they may be naturally present in the environment or may be introduced in the system by the man-made activities, such as the industrial and agricultural effluents. These pollutants have the tendency to remain in the system (because of non-degradability) and thus accumulate over time resulting in the concentration that is distinctly too harmful to the
ecosystem, and to the individual members like plants, animals and human beings.

While keeping these points in mind, the present study was carried out to understand the effects of above mentioned pollutants on the physiological and biochemical during germination, seedling growth, vegetative growth, and on the yield attributes were investigated.

The seeds of mung (green gram, Phaseolus aureus Roxb. cv. K-851) were germinated and the seedlings were allowed to grow at the room temperature for 120 hours in the presence of one of 150 ppm each of ZnCl$_2$, CdCl$_2$, and NaF solutions. Distilled water served as the control. The data on germination percentage and seedling growth, as well as on the biochemical constituents (protein, total and reducing sugars, phenols, and free amino acids) and enzyme activities (protease, invertase, peroxidase, and IAA oxidase) at an interval of every 24 hours were recorded and analyzed. These constituted a first set of experiments.

In another experiment set, the seeds of mung were sown in the earthen pots filled with soil and manure. These were provided with the above mentioned test solutions and distilled water, and the plants were allowed to grow under the green-house conditions. The data on vegetative growth at an interval of 15 days and
on the final yield attributes were acquired and analyzed.

The following are the salient features of the present studies:

**SALIENT FEATURES**

- The germination percentage was enhanced by the Zn treatment, while it was reduced by the treatments with Cd and F. The rate of germination was faster in the Zn-treated seedlings.

- The seedling/plant growth reduced critically by the Cd and F treatments, the shoot growth was affected more in both. Zn, being an essential element for plant growth, enhanced the growth slightly.

- The fresh and dry weights of cotyledons and embryo axis were severely affected by Cd and F, while Zn showed some beneficial effects.

- The moisture content of seedlings also reduced on the treatments with Cd and F.

- Cd and F arrested the events in carbohydrate metabolism, the effect was more drastic in the case of Cd, which reduced the reducing sugars, and invertase activity. Zn showed slight positive effect.
High total sugar and low reducing sugar levels may signify the strategies to survive Cd stress. Inadequate hydrolysis of polysaccharides to simple reducing sugars could be an adaptation to conserve and provide energy for the later stage of growth, as a result the instantaneous growth was affected due to a less energy supply.

The protein metabolism was also disorganized by Cd and F treatments, former affecting it drastically. The free amino acids assumed a high level. The protein level fell down by these treatments, which probably affected the immediate growth. Seedlings/plants, by maintaining high amino acid level, were trying to come through the metal stress and this maybe due to a limited capacity synthesize proteins, and hence amino acids accumulated.

The protein level was also reduced by Cd and F, which may also be a reason for the poor growth. Zn treatment invoked a favourable response, partly due to a micronutrient and co-factor for many enzyme systems.

The protease activity reduced initially by Cd and F treatments, but was offset later on by an increase, perhaps there was a reversal or removal of inhibition.
The treatments of Cd, Zn and F altered the electrophoretic profile of the growing seedlings. An increase in the low molecular weight proteins and a decrease in high molecular weight proteins with seedling growth in presence of Cd or F suggest increased degradation of high molecular weight storage proteins.

Like other enzyme activities, IAA oxidase and peroxidase activities were also inhibited by Cd and F. Zn enhanced these activities. The trend reversed in the final phase. More IAA degradation by increased oxidase activity could justify the inferior growth. While, system with a reduced peroxidase activity could not annihilate \( \text{H}_2\text{O}_2 \) proving toxic for growing seedlings/plants.

The level of phenols was reduced by Cd and F, but they rose later on. A converse trend was shown by Zn. The levels reversed later with growth. Phenols may act as promotors or inhibitors of growth. In the present case, phenol content correlated with the degree of growth only initially. Later, an inverse relationship was noticed indicating a rise in inhibitory phenols.
The total dry and fresh weights of plants grown under field condition were reduced by Cd and F treatments. Zn elevated these.

The leaf production (number and weight) was reduced by Cd and F. This may account for the lowered photosynthesis, and hence the altered growth.

The fruit number and fruit weight were recorded significantly low in Cd treated plants.

The seed number per fruit and per plant were also highly diminished in Cd treated plants. F treatment did not have substantial effect on these parameters.

Growth indices, like NAR, LWR, RGR and BMD, were influenced by Cd, but insignificantly.

In the case of harvest index, effects of treatments were not evident clearly. Thus, these pollutants, though, reduced the growth, did not alter the yield.
CONCLUSIONS

It can, thus, be concluded from these findings that pollutants like cadmium, zinc (though being a micronutrient) and fluoride certainly affect the processes of plant, both physiological and the biochemical. Among these, cadmium and fluoride appeared to be inhibitory to majority of processes, while zinc emerged as a promotor of all these processes. Fortunately, the effects of the pollutants, whether positive or negative, were nullified during the course of vegetative growth of plants, and very little residual effects were noticeable in the final yield. Thus, plants could adapt well to the stress to which they were subjected, endured the stress, and came through successfully leaving no after-effects.